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Cover photograph: modified image of male *Lissotes crenatus*

Rediscovery of the endemic Tasmanian stag beetle *Lissotes crenatus* (Westwood, 1855) (Scarabaeoidea: Lucanidae: Lucaninae): collection history, distribution and ecological notes.

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Introduction

The geographical distribution of the flightless stag beetle, *Lissotes crenatus* (Westwood, 1855), has been an entomological mystery for over 200 years. The species description was based on a single male specimen that was collected by the French during their voyage of discovery to the southern lands between 1800 and 1804. The type location for this beetle was recorded simply as *Nova Hollandia*, the historical European name for mainland Australia. This inexact locality has hindered researchers and enthusiasts in determining and finding the actual habitat for this species. This paper discusses the history of the type material and extrapolates on where the type specimens may have been found; gives more concise information on the distribution of *L. crenatus* in Tasmania; gives ecological notes on the variety of habitats; and provides some biological information on this species.

Tasmanian Lucanidae

The world stag beetle (Lucanidae) fauna comprises around 1700 species. Australia is home to a diverse fauna of 95 species in 18 genera, representing around 7% of the global total of Lucanidae species (Hangay & de Keyzer 2017; Bartolozzi *et al.* 2017). At just over 64 000 km^2, Tasmania is a relatively small island yet it hosts a rich lucanid fauna of 33 described species in five genera. The endemic flightless species in the subfamily Lucaninae are the most speciose. The genus *Hoplogonus* contains three species that are confined to the wet forests of north east Tasmania (Meggs *et al.* 2004; Threatened Species Section 2012), and the genus *Lissotes* has 25 endemic Tasmanian species, many of which have relatively discrete distributions (Meggs & Taylor 1999; Meggs & Munks 2003; Bartolozzi *et al.* 2017; Richards & Spencer 2018). In addition to the known taxa, several undescribed *Lissotes* species have been identified in private and public entomology collections, including that held by the Queen Victoria Museum and Art Gallery (R de Keyzer pers. obs.).

Plate 1. A pair of *Lissotes crenatus* found *in copulo* at Grassy, King Island (QVM.2019.12.0617).

Lissotes species are primarily inhabitants of relatively humid forests and have saproxylic larvae associated with decomposing timber (Hangay & de Keyzer 2017).

The Lucanidae in general are well known for extreme male positive sexual size dimorphism, with many species displaying ornate mandibular development used to defend potential mates, food resources or both from rival males (Emlen & Nijhout 2000; Fearn 1996; Fremalin 2009). In addition, allometric development of the male mandible is common in the Lucanidae and has resulted in taxonomic uncertainties when only small sample sizes are available for study (Hangay & de Keyzer 2017). The genus *Lissotes* is no exception, with the taxonomic status and species boundaries of some species confounded by a lack of suitable sample sizes across the full spectrum of male mandibular development (Hangay & de Keyzer 2017). There are six obscure Tasmanian stag beetles (*L. crenatus, L. convexus*, *L. distinctus*, *L. forcipula*, *L. politus*, and *L. subcrenatus*) that have poorly resolved taxonomy because they are known from a single specimen or a small sample size (Hangay & de Keyzer 2017). Adding to this problem is a lack of useful or concise locality data that can be used to facilitate finding additional material of these species. Historically it was not deemed necessary to record more exact data, nor was it technologically possible to record more concise collection data. In this work we report on the collection of 36 male and seven female *L. crenatus* from three islands in western Bass Strait, a further two specimens unknowingly held in another Australian museum, and a single specimen held in an overseas collection that was mistakenly identified as an additional specimen of *L. crenatus*.

Description of *Lissotes crenatus*

John Westwood, entomologist with the University of Oxford in England, described, in Latin, the male of *L. crenatus* in 1855. Unfortunately in his description he does not mention how many male specimens were examined but it is quite likely he has only used a single male specimen to describe this species. Later, in 1871, Westwood refers for the first time to the existence of a female *L. crenatus* when describing *L. subcrenatus* from a single female specimen (Westwood 1871).

In the Hope Entomological Collections at the Oxford University Museum of Natural History there is both a male and female specimen that have been labelled as type material of *L. crenatus* (Bartolozzi *et al*. 2017). While the female specimen of *L. crenatus* has been labelled as a type it has no such status as Westwood (1855) did not describe the female of *L. crenatus*. As such it cannot be considered as a name-bearing type specimen as it does not meet the provisions of Article 73 of the International Code of Zoological Nomenclature. What is also clear based on our examination of a pair of specimens caught in copulation on King Island (Plate 1) is that this female specimen is definitely the female of the male type specimen.

Both Boileau (1913) and Bomans (1986) have raised doubts about the type status of the male specimen in the Hope Entomological Collections but Boileau thought the male type specimen did correspond with Westwood's description. Bomans was concerned that the male specimen did not have data labels in accordance with Westwood's description – '*Dorcus crenatus*, Latr. MSS.? Voy. de Péron.' The labels of the type male specimen are illustrated in Bartolozzi *et al.* (2017, p. 105) and clearly show there is no such label, nor is there a label indicating the type locality of '*Nova Hollandia*.' While Bomans also had concerns about the size of the specimen and its damaged condition he did not suggest that the male specimen should not be considered as being that of *L. crenatus*.

Whether this male specimen is the type of *L. crenatus* or not, it is clearly a specimen of this species (R de Keyzer, pers. obs.). All *L. crenatus* specimens mentioned in this paper have been identified by the third author by comparison with detailed photographs of the male type specimen and the female specimen in the Hope Entomological Collections and by using the Westwood (1855) description.

From collection to description

The male type of *L. crenatus* was collected by the French zoologists that were part of Commander Nicholas Baudin's voyage of discovery to the southern lands, *Expédition aux terres australes* (1800–03). From 1801 to 1803 Baudin's fleet charted the coast of mainland Australia and Tasmania, and at every opportunity the zoologists, led by François Péron, went ashore to collect and study the fauna (Jones 2017; Péron & de Freycinet 1824; Baudin 1800–03). In all, they accumulated 18 414 animal specimens for the Muséum National d'Histoire Naturelle, Paris. Unfortunately, by that time (1804) the 'appetite' for discovery had waned and it took decades for the collections to be worked through. Eventually 3872 species were recorded, of which 2542 were new to science (Jones 2017); *L. crenatus* was one of these new species.

It was half a century after Baudin's fleet returned to France before *L. crenatus* was described by John Obadiah Westwood (1805–93) at the University of Oxford, England. It is unclear how and when the specimen was transferred from Paris to Oxford; however, Westwood (1855) states that French entomologist Hippolyte Louis Gory (1800–52) forwarded it to the English clergyman and entomologist Frederick William Hope (1797–1862), at the Oxford University (Foote 2018).

The Darlington specimen

There is only one other record of *L. crenatus* being collected (Hangay & De Keyzer 2017; Bomans 1986); however, this was an incorrect identification by Bomans and the specimen is likely to be a male specimen of *Lissotes forcipula* (Westwood, 1871) (R de Keyzer, pers. obs.) (Plate 2). This specimen was collected by the American entomologist PJ Darlington Jr from Mount Wellington between December 1956 and April 1957 (Darlington 1960). It resides in the collections of the Museum of Comparative Zoology, Harvard, Massachusetts (MCZENT00743590). In 1983 HE Bomans mistakenly identified this specimen as *L. crenatus* and published information on this specimen in 1986. Bomans was aware that the collection of the male type specimen of *L. crenatus* was attributed to Péron during the French voyage of discovery to Australia, and he made an incorrect assumption that if Darlington had found *L. crenatus* on Mount Wellington, then so had the French zoologist when the vessel *Géographe* visited Hobart in January 1802 (Bomans 1986). This incorrect identification confounded the actual distribution of *L. crenatus* and it remained a mystery until recently.

Lissotes crenatus discovered in the QVMAG collection

In May 2017 the third author identified five *L. crenatus* specimens in the QVMAG collection. These had been collected from two islands in Tasmania's north west. The first author had collected a male in January 2017 on Three Hummock Island (QVM.2017.12.1202), and another four males had been collected from Albatross Island: two by RH Green in 1973 (QVM.2017.12.1042-1043) and two by E Richardson in 1989 (QVM.2017.12.1040-1041) (Plate 3; Table 1).

The discovery of *L. crenatus* from the Hunter Group was a surprise as it had been assumed that the species was located on Mount Wellington. Over the following two summers more specimens were found on Three Hummock Island: three males (including one live specimen) during December 2017 (QVM.2018.12.0751-0753), and a further three specimens across the new year of 2018–19 (QVM.2019.12.0644-0646) (Table 1).

These 11 specimens were evidence that *L. crenatus* was extant on two islands in western Bass Strait. This led the first author to research the journals of Nicholas Baudin to understand if his crew had the opportunity to collect the type specimen from this region.

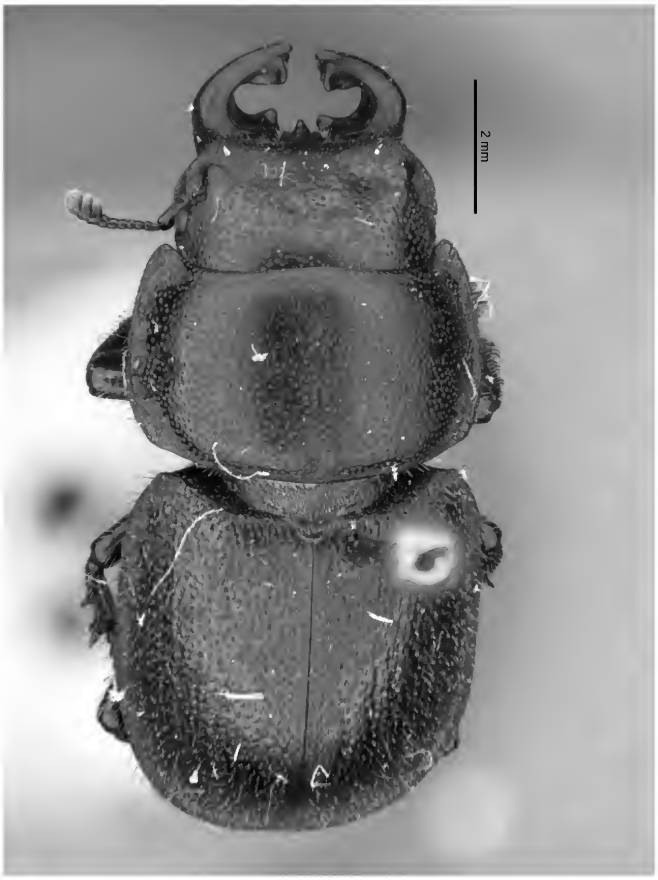

Plate 2. The specimen of *Lissotes* collected by PJ Darlington Jr from Mount Wellington between December 1956 and April 1957 (MCZENT00743590). This was incorrectly identified as *L. crenatus* by Bomans (1986) and is likely to be a male of *Lissotes forcipula*. Photograph provided by the Museum of Comparative Zoology, Harvard University. Photograph by Charles (Whit) Farnam.

So, where was the type material likely collected?

The French naturalists most likely collected the two specimens of *L. crenatus* at the southern end of Sea Elephant Bay on King Island. However, it is remotely possible but improbable that they came from Three Hummock Island or New Year Island.

King Island

On 7 December 1802 Baudin's corvette *Géographe* and the schooner *Casuarina* were anchored near present-day Naracoopa in Sea Elephant Bay, King Island (anon 2016; Baudin 1800-1803, p. 439). The *Casuarina*, under the command of Louis de Freycinet, was sent to chart the Hunter Group to the south east. At the same time Baudin launched a large boat (a dinghy) for the geographer Pierre Faure to circumnavigate King Island. Three days after these vessels departed, the fleet's naturalists, led by François Péron, went ashore at Sea Elephant Bay to set up an observatory at the southern extent of Fraser Beach near what is today the township of Naracoopa, close to the location 39° 55′ 13″ S 144° 07′ 28″ E (Figure 1) (Baudin 1800-1803, p. 445). This part of the shoreline is sheltered from westerly, south westerly and south and south easterly winds, and is protected to the east-north-east by a low rocky outcrop. Fresh water was available to the naturalists 60 metres to the west. Today this is known as Bronzewing Creek. Rankin Creek is a further 600 metres to the north west.

The crew of the English schooner *Cumberland* visited the French tents on 11 December, describing the location as '*... a fine sandy beach with several runs of freshwater; the north-east*

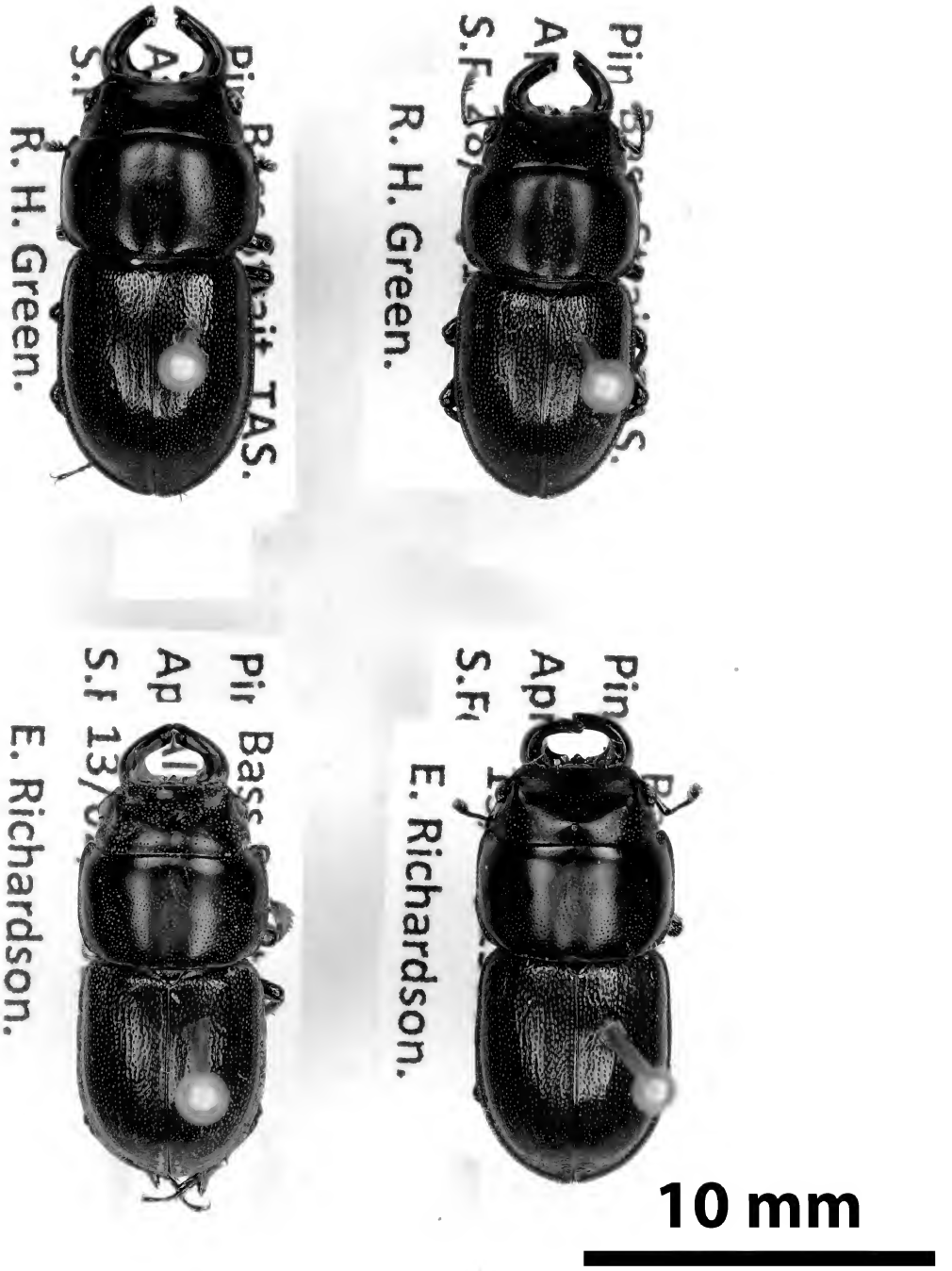

Plate 3. Specimens of *Lissotes crenatus* collected from Albatross Island by RH Green in 1973 (top) and E Richardson in 1989 (bottom) (QVM.2017.12.1040-1043).

part rocky.' (Flemming 1802–03). There is no description of the vegetation in the vicinity of the observatory; however, Flemming recorded some observations of the vegetation at the northern end of Fraser Beach. He described the country around the location of the English sealers' huts, located near 39° 51' 33" S 144° 06' 34" E (Figure 1). This was about 7.5 kilometres to the north of the French tents, and was *'... high and sandy about half a mile in deep black vegetable mould, mixed with sand; timber small. There are the remains of some very large gum trees, but they are all rotten; the low ground is swampy.'* This general description of the vegetation (small timber, large eucalypts and swamp) is repeated for nearly all the sites visited by the crew of the *Cumberland* across the northern half of King Island (see Flemming 1802-03), and is conducive to the presence of saproxylic beetles like *L. crenatus* in the forest/woodland behind Sea Elephant Bay in 1802.

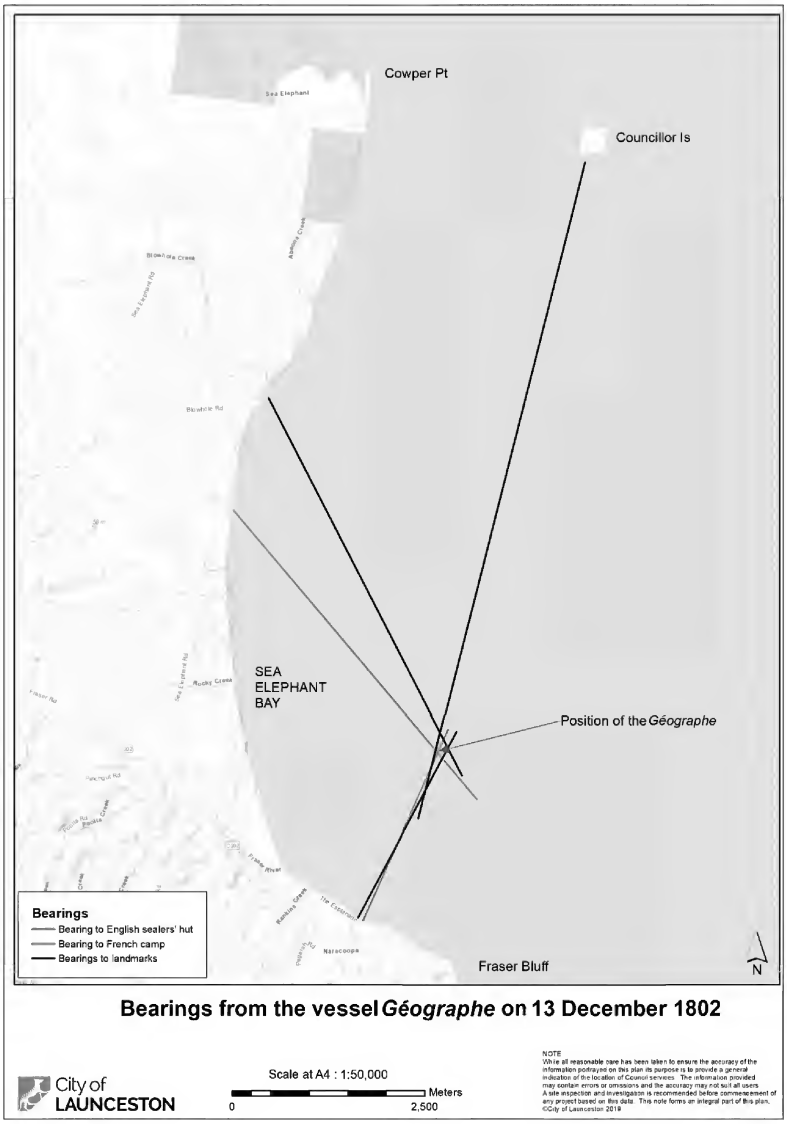

Figure 1. Bearings taken from the corvette *Géographe* on 13 December 1802. These bearings identify the location of the French camp (red) and the English sealers' hut (yellow) at Sea Elephant Bay, King Island. The French camp is close to where the authors collected *Lissotes crenatus.* The English recorded observations of the vegetation near the hut.

The French naturalists were ashore from 10 to 24 December and Péron later recounted the wide variety of new animal species that were collected (Baudin 1800-1803; Péron & de Freycinet 1824). It is highly likely that, because of the skilled and focussed collectors involved, and the time dedicated to fieldwork, *L. crenatus* was collected in vegetation behind the southern end of Sea Elephant Bay, King Island (Figure 2, green dot).

Three Hummock and New Year Islands

During this same period, the crew of the *Casuarina* were charting the Hunter Group. The only record of de Freycinet going ashore was on 11 December at Coloumb Bay, Three Hummock Island, where some geological specimens were collected (Baudin 1801-1803) (Figure 2, blue dot). This location is in the west of the island and although it is possible that *L. crenatus* was collected at that site, it is very unlikely. De Freycinet was a navigator, not a naturalist, and the location at which he went ashore was (and still is) dominated by windswept coastal scrub on alkaline dunes (DPIPWE 2014; *Empire* 1863). This is not the preferred habitat for *L. crenatus*. Also, this area has been extensively searched by the first author since 2015 and no specimens of *L. crenatus* have been found.

Similarly, during Faure's circumnavigation of King Island, the crew went ashore for three days at New Year Island, north west of King Island (Figure 2, blue dot). This was during bad weather and they stayed with resident English sealers. Again, it is possible but not probable that *L. crenatus* was collected from New Year Island.

Based on this research, the first and second authors visited King Island in early 2019 to search for *L. crenatus* near the site that Péron went ashore in 1802 (discussed later).

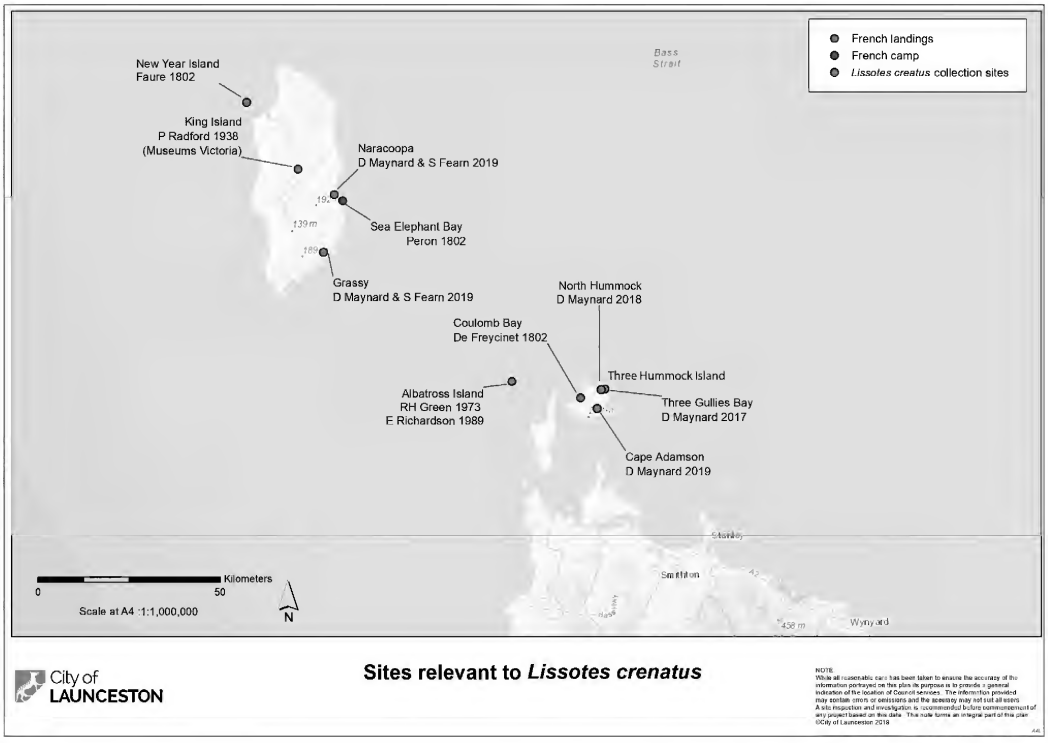

Figure 2. The locations visited by Nicholas Baudin's fleet in 1802, and the locations from which *Lissotes crenatus* has been collected.

Collection of the Three Hummock Island specimens

Between 2015 and the present, the first author has conducted 27 field days on Three Hummock Island sampling insects (D Maynard unpublished data; QVMAG database). Most of this effort was on the west, north and east coasts, extending inland less than 1.5 kilometres, and only in areas of relatively easy access. This has left much of the island unexplored by the first author. Targeted, intensive searching for *L. crenatus* over three summers turned up only seven specimens (Plate 8; Table 1). This may imply that the species survives in low densities, or as much of the island remains unexplored, it may be that the species is more abundant in other areas and habitats on the island.

To date, *L. crenatus* has been found at three locations on Three Hummock Island (Figure 2, yellow dots), all in areas of disturbance within *Leptospermum glaucens/L. scoparium* heathland and scrub.

The Three Gullies Bay site

Four of the seven specimens were found on an abandoned earthen landing strip in the north east of Three Hummock Island (centred on 326317mE 5525506mN). This hard-packed strip of land was fringed with *Leptospermum scoparium* and *Melaleuca squamea*; *Leptospermum glaucescens*, *L. nitidum, Acacia mucronata*, *Banksia marginata* and other heathland and scrub was encroaching onto the airstrip. The strip is bounded to the south by *Eucalyptus nitida* forest and woodland, and to the north by western wet scrub in the east, and *Leptospermum glaucescens* heathland in the west (DPIPWE 2014). One specimen (QVM.2017.12.1202) collected on 25 January 2017 was found dead amongst sparse leaf litter on the edge of the airstrip. The remaining three specimens (QVM.2018.12.0751-0753) were collected on 29 December 2017 from below fallen dead *Leptospermum scoparium* bordering a vehicular track along the southern side of the airstrip (Figure 2; Plates 4 and 5).

Plate 4. The collection location of one *Lissotes crenatus* specimen near Three Gullies Bay, Three Hummock Island. The dead and fallen *Leptospermum scoparium* borders a vehicular track.

Plate 5. A live male *Lissotes crenatus* (QVM.2018.12.0753), found in the dry humus and soil below a *Leptospermum scoparium* stump near Three Gullies Bay, Three Hummock Island.

The North Hummock site

Two dead male specimens (QVM.2019.12.0644-0645) were found in an area of disturbed *Leptospermum glaucescens/ L. scoparium* scrub 1.050 kilometres west of the landing strip collection site (325282mE 5525322mN) on 31 December 2018. They were found separately amongst the coarse woody debris (Figure 2; Plate 6).

Cape Adamson site

The head and mandibles of a male *L. crenatus* were found amongst coarse woody debris on the edge of a vehicular track running through *Leptospermum glaucescens/L. scoparium* scrub about five kilometres south of the other two sites (324168mE 5520302mN) on 1 January 2019 (Figure 2; Plate 7).

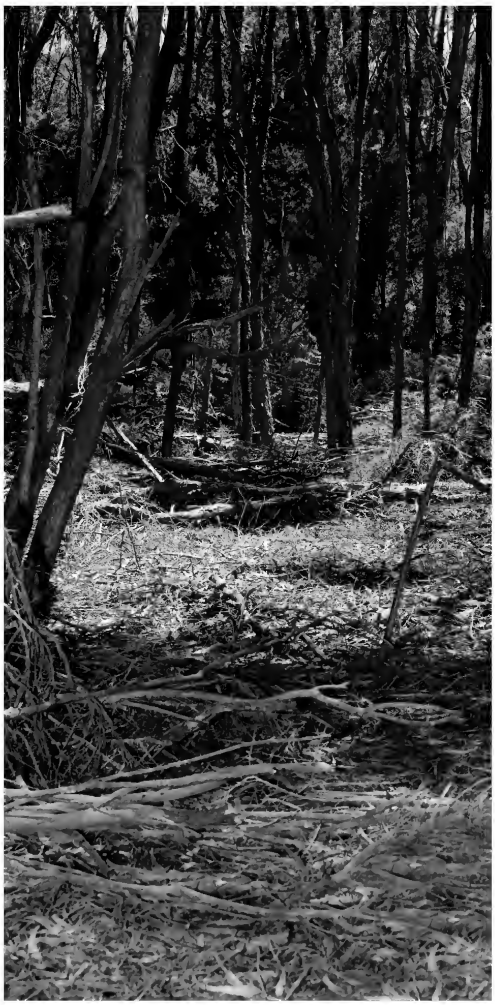

Plate 6. The collection location of two male *Lissotes crenatus* (QVM.2019.12.0644-0645) near the North Hummock, Three Hummock Island.

Plate 7. The collection site of the head and mandibles of a dead male *Lissotes crenatus* (inset; QVM.2019.12.0646), located inland of Three Gullies Bay, Three Hummock Island.

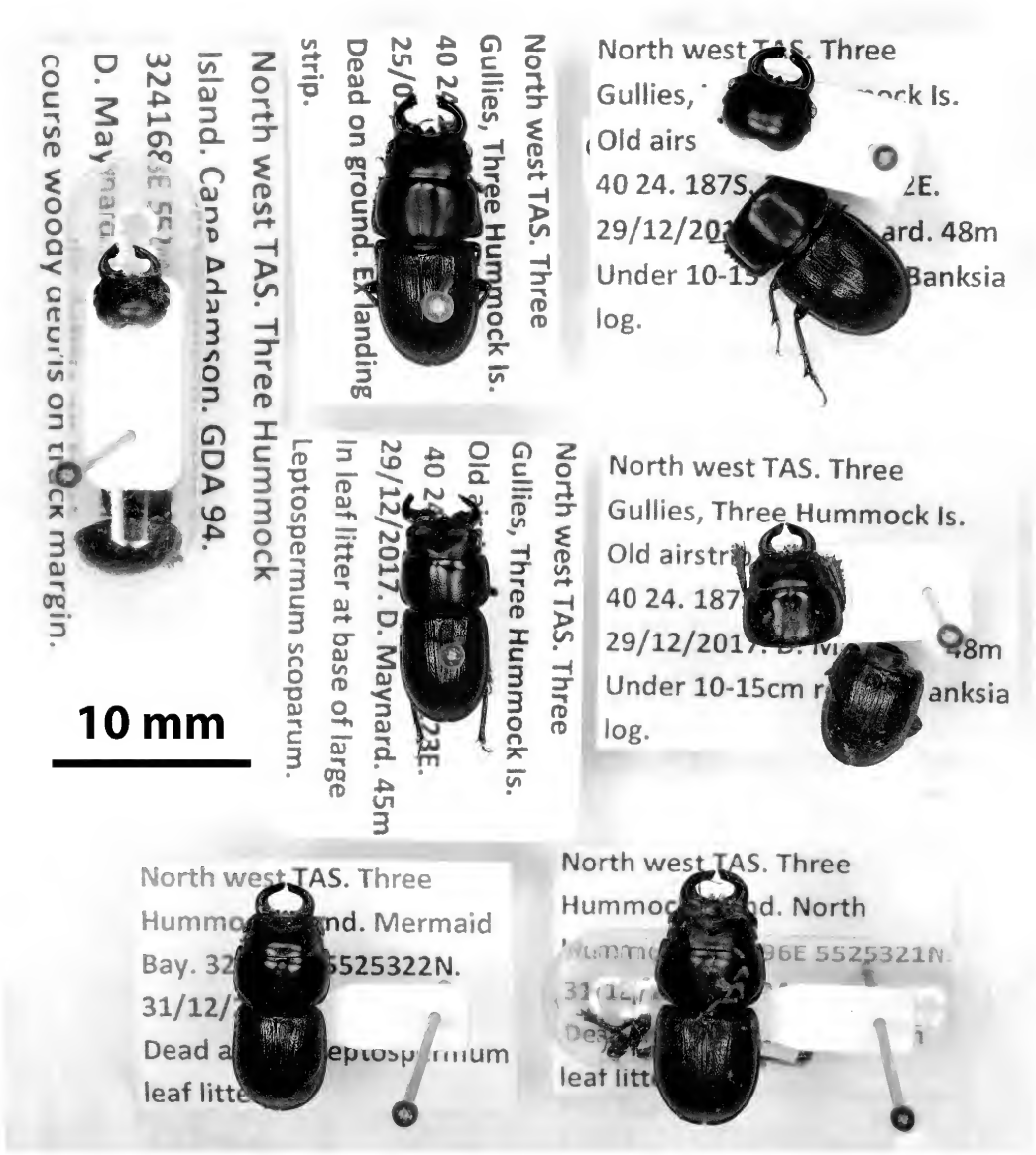

Plate 8. The specimens of *Lissotes crenatus* collected from Three Hummock Island between 2017 and 2019 (QVM.2017.12.1202; QVM.2018.12.0751-0753; QVM.2019.12.0644-0645).

Island	Nearest name place	Collection date	Collector	Male	Female	Registration numbers
Albatross Island	Albatross Island	28/01/1973	RH Green	2		QVM.2017.12.1042-1043
		13/02/1989	E Richardson	2		QVM.2017.12.1040-1041
Three Hummock Island	Three Gullies Bay	25/01/2017	D Maynard	1		QVM.2017.12.1202
		29/12/2017		3		QVM.2018.12.0751-0753
	North Hummock	31/12/2018		2		QVM.2019.12.0644-0645
	Cape Adamson	1/01/2019		1		QVM.2019.12.0646
King Island	Naracoopa	31/01/2019	D Maynard & S Fearn	3		QVM.2019.12.0641-0643
	Grassy	3 & 5/01/2019		22	7	QVM.2019.12.0613-0640

Table 1. The holdings of *Lissotes crenatus* at Queen Victoria Museum and Art Gallery at the time of publication.

Plate 9. A rookery on Albatross Island in 1895 featuring nests amongst the dead branches of *Disphyma* in the foreground, and live tussock grasses in the background (Ashworth & le Souëf 1895).

The Albatross Island specimens

Unfortunately RH Green (1925-2013), former curator of Zoology at QVMAG, and Elizabeth Richardson did not provide any field notes with their specimens from Albatross Island, and until further collecting occurs we can only hypothesise about the habitat availability/preferences of *L. crenatus* on this island.

The vegetation of Albatross Island is restricted to a few low-growing species; trees and large shrubs are absent (Green 1973; Brothers *et al.* 2001). The dominant plant species, present in varying proportions across the island, are the rounded noon flower (*Disphyma crassifolium*), rookery senecio (*Senecio* sp.) and coastal tussockgrass (*Poa poiformis*) (Brothers *et al.* 2001). This vegetation seems to be unchanged since Ashgrove and le Souëf visited in 1895 (Plate 9). However, it is very likely that the amount of area covered by vegetation varies through the year in response to the presence of breeding birds. For instance, between August and May each year the breeding population of the shy albatross (*Thalassarche cauta*) on the island reaches about 5000 breeding pairs (Brothers *et al.* 2001). These birds appear to trample all vegetation in rookery areas with the exception of the tussock grasses (Plate 9).

This mix of low vegetation, combined with the seasonal trampling, would suggest that *L. crenatus* completes its lifecycle in the tussock grasses, the humus/guano layer, rock crevices and/or the non-rookery parts of the island. There is even the possibility that the beetle can live in the decaying bases of the albatross nests; Ashworth and le Souëf (1895) were able to collect worms from the '... decayed interior of the nest.' The available habitat on Albatross Island is quite different to that of the collection sites on Three Hummock Island and King Island.

Collection of the King Island specimens

The first and second authors sampled *L. crenatus* from two locations in south east King Island. The habitat from which these specimens were collected was markedly different from that on Three Hummock Island and Albatross Island.

The Naracoopa site

Three male *L. crenatus* (QVM.2019.12.0641-0643) were collected at a site (centred on 251907mE 5578763mN; Figure 2) adjacent to the Fraser River and less than one kilometre north of the township of Naracoopa. This site was also about 0.8 kilometres inland from Fraser Beach, Sea Elephant Bay and about three kilometres north east of the site at which François Péron camped in 1802.

This habitat was categorised as *scrub complex on King Island* (DPIPWE 2014). It comprises a mix of *Eucalyptus*, *Acacia*, *Banksia* and *Leptospermum* trees and an understory dominated by sedgeland/heathland species. Open ground was covered in dry leaf litter and fallen timber (Plate 10). The *L. crenatus* specimens were found under rotting logs 150 to 180 millimetre diameter situated above the flood level of the Fraser River.

This site is adjacent to about 1800 hectares of vegetation complex that also includes *Leptospermum* forest, *Eucalyptus globulus* wet forest, hardwood and softwood plantation, and a scrub complex (DPIPWE 2014). A number of hours were spent searching along a transect through a small part of this adjacent site, but no *Lissotes* were found.

The Grassy site

Twenty-two male and seven female *L. crenatus* (QVM.2019.12.0613-0640) were collected within a 1.4 hectare search area (centred on 248966mE 5563063mN) on the steep banks (15-30°) of a small tributary within the approximately 270-hectare Grassy River drainage system. The vegetation type at this site was *Leptospermum* forest (DPIPWE 2014), dominated by 5 to 10 metres tall *Leptospermum* spp. mixed with *Acacia melanoxylon*, *Banksia marginata* and *Atherosperma moschatum*, producing a closed or semi-enclosed canopy. The sparse understory was dominated by *Ghania* sp. and *Dicksonia antarctica* along the stream edges. The ground was covered in leaf litter and fallen timber (Plate 11).

The specimens were present under aging timber 150 to 300 millimetre diameter, as either single males or females, or males and females in close proximity. In one case, a male-female pair was found *in copulo* (QVM.2019.12.0617) (Plate 1); this represents the first verifiable female of the species.

Plate 10. The second author at the collection site of three male *Lissotes crenatus* (QVM.2019.12.0641-0643) at Fraser River, King Island.

Plate 11. Two habitat images at the collection site of 29 male and female *Lissotes crenatus* (QVM.2019.12.0613-0643) at Grassy, King Island.

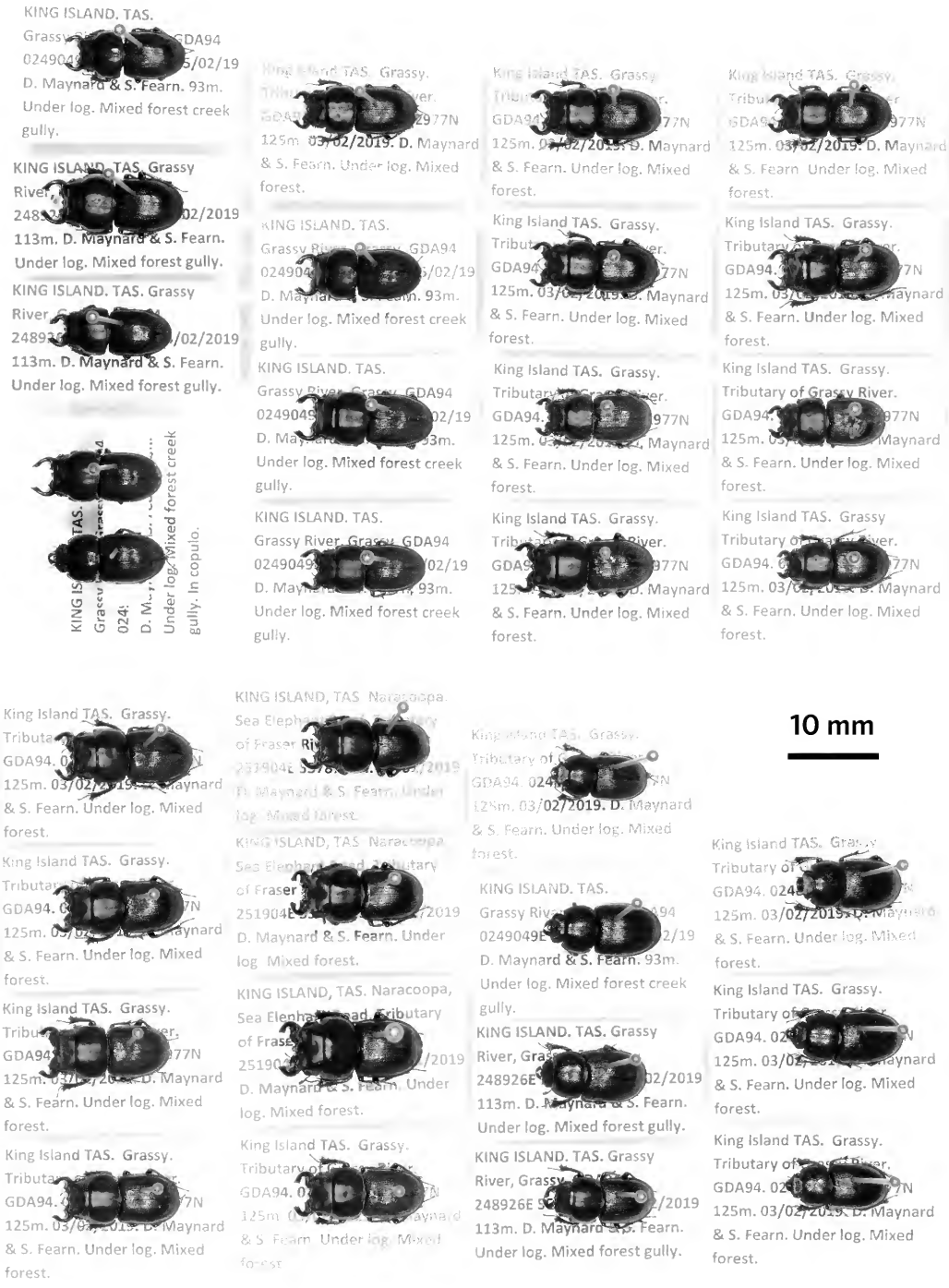

Plate 12. Specimens of *Lissotes crenatus* collected from King Island between 30 January and 6 February 2019 (QVM.2019.12.0613-0640).

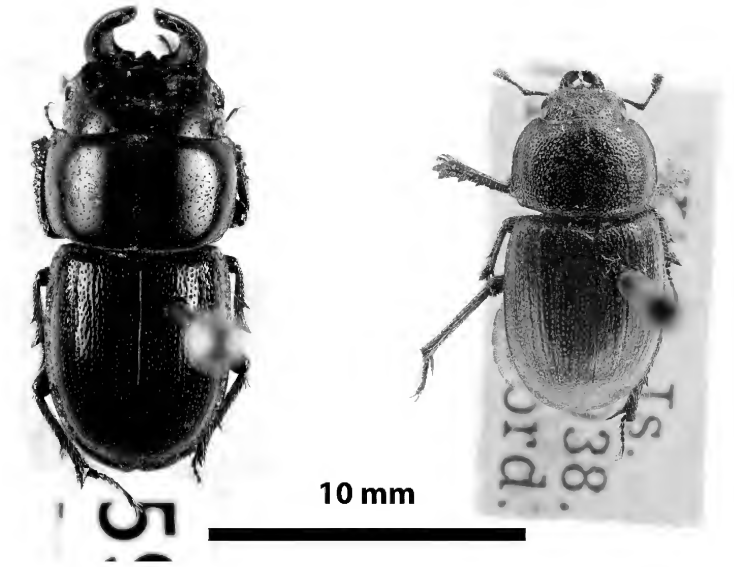

Plate 13. Two *Lissotes crenatus* specimens held by Museums Victoria. Left: adult male (COL-86559); right: adult female (COL-86497).

Specimens in other public collections

The authors sought to document all of the specimens of *L. crenatus* held but unidentified in Australian museums and other publicly owned collections. Just two specimens were located. Museums Victoria holds an adult male (COL-86559) and an adult female (COL-86497), both collected from King Island by P Radford in January 1938 (Plate 13). These had been identified as *L. punctatus* by Lea.

Distribution and habitat

Lissotes crenatus appears to be restricted to some or all of the islands of western Bass Strait. It has been collected from King Island, Three Hummock Island and Albatross Island, and more search effort in the Hunter Group is required to fully document this species distribution.

It appears that *L. crenatus* is absent from mainland Tasmania. Between 1 and 6 January 2017 and again on 27 January 2018 the senior authors sampled 25 sites across Woolnorth Point in far north west Tasmania. This is the closest part of mainland Tasmania to the known insular populations of *L. crenatus*. The survey produced hundreds of beetles, including a rich assemblage of saproxylic species associated with decomposing logs of a variety of tree species that were abundant at most sites (see Maynard & Fearn 2018). No *Lissotes* of any species were found. It may be that the entire distribution of *L. crenatus* is restricted to the islands off north west Tasmania.

The available information suggests that *L. crenatus* is an ecologically flexible species. The habitats on the three islands from which it is recorded are diverse and different. This is particularly the case for Albatross Island. It is widely accepted that the larval stages of *Lissotes* are saproxylic and associated with decomposing timber (Hangay & de Keyzer 2017), however there is no woody vegetation on Albatross Island (Brothers *et al.* 2001). This population of *L. crenatus* may be uniquely adapted to utilising humus, *Poa* sp. or even albatross nests for its larval stages.

Ecological flexibility has probably been an important factor in this species' survival through approximately 10 000 years of sea level rise which has created isolated

populations on these islands. Through that time, vegetation types, communities and cover on each of the islands would have changed in response to the changing climate and available resources. This stag beetle has been able to adapt over this duration to not only climatic changes but it has also managed to survive the rapid changes that have occurred since the arrival of Europeans. Over the last two centuries many of these islands have undergone considerable change. Attempts to farm Three Hummock Island, combined with uncontrolled fires, and more recently renaturalisation have seen dramatic changes in the vegetation (Brothers *et al.* 2001; Bryant *et al.* 2008). Robbins and Walker Islands (privately owned) and Hunter Island (under lease) have had a similar history of anthropisation, and continue to support agriculture (Natural and Cultural Heritage Division 2017; Harris & Lazarus 2002; Elson 2017). Albatross Island has not been modified by Europeans as such; however, in the early 1800s the overharvesting of albatross for their feathers, meat and eggs (Green 1973; Alderman *et al.* 2011; Parks and Wildlife Service 2000), and in later years their guano (*Launceston Examiner* 1861), may have altered the island's ecology. Yet *L. crenatus* has been found on three of these five islands (Robbins and Walker Islands have not been surveyed). The remaining smaller islands in the region (including but not limited to Stack, Trefoil, Penguin and Bird Islands) remain *relatively* unchanged since European arrival (see Brothers *et al.* 2001 for more information), and it may be that *L. crenatus* is a resident.

Historical human impacts on King Island have been most severe where clearing and fires have reduced the extent of native vegetation by more than 90% in some areas. Entire vegetation communities have possibly been eliminated altogether or now only exist as remnant stands; this is especially so for forest communities (Barnes *et al.* 2002). *Lissotes crenatus* on King Island was located only in remnant wet forest in the south of the island. Such forest originally covered much of the eastern half of the island but was converted to pasture after 1888 when the Tasmanian Government opened King Island up to settlers (Barnes *et al.* 2002). The authors sampled only a relatively small portion of available and apparently suitable remnant *L. crenatus* habitat on King Island but it appeared to be relatively common.

Discussion

To date, *Lissotes crenatus* has been collected from three very different habitats. King Island's mixed forests best represent the 'typical' habitat of *Lissotes*; all specimens found at the Grassy site were alive and about one third were females. On Three Hummock Island only males were found, and all but one were dead. It may be that roaming males were caught in unfavorable environmental conditions (hot and dry) on the exposed edges of the *Leptospermum* scrub, and that the population is centered on nearby forests. The presence of *L. crenatus* on Albatross Island in the 1970 and 80s is very unusual. More work is needed to identify that the species is extant on that island and to understand its ecology.

The Grassy site provided us with probably the best insight into the species. The survey took about three hours and in that time about 0.5% of the vegetated Grassy River catchment was searched; 22 males and 7 females were found. This translates to 20 beetles per hectare. If this catchment provides a uniform, suitable habitat across the 270 hectares then it is possible that this one site hosts around 5800 *L. crenatus*. This crude estimate at least provides an order of magnitude of the possible population but of course more data are required to generate an estimate in which we can have confidence.

The land tenure classification for Grassy site is Private Freehold which does not provide immediate protection to this *Leptospermum* forest habitat. However, the steep topography along the tributaries is unlikely to be cleared to support agriculture. Regardless of its possible future use, this is not the only available habitat for *L. crenatus* in the area. To the south west of the township of Grassy are about 750 hectares of the same vegetation type. Again, much of this habitat is on Private Freehold land except for about 190 hectares

for which the land tenure classification is Conservation Covenant (DPIPWE 2015, 2017). The same area supports about 400 hectares of King Island eucalypt woodland and *Eucalyptus globulus* forest (DPIPWE 2014) which is likely to support *L. crenatus*. More fieldwork is needed to understand the habitat use and population size of *L crenatus* in this area.

Future research

The distribution, abundance and population dynamics of *L. crenatus* is unknown. A survey of the islands in the King bioregion is required. This would also help us to understand the larval food sources. Molecular studies would provide a better understanding of the relationships between discrete (island) populations. The remarkable differences in habitats utilised by this species may have already had consequences on speciation in response to varied food resources as well as temperature and moisture variability.

It is important to understand how sympatry with other *Lissotes* species affects *L. crenatus*. *Lissotes crenatus* is the only stag beetle known to occur on Albatross Island. However, *L. desmaresti* (or possibly a new species close to *L. desmaresti)* has been collected on Three Hummock Island and King Island. Also, *L. launcestoni* was collected from King Island in the 1930s.

Conclusion

The flightless stag beetle *Lissotes crenatus* is extant on at least two islands in western Bass Strait and appears to be ecologically flexible, allowing it to live in a range of habitats. This species has managed to survive considerable habitat loss and change since European arrival. More work is needed to evaluate the conservation status of this species. It is likely that the type material collected by François Péron in December 1802 originated from vegetation behind Sea Elephant Bay, King Island. QVMAG holds 42 of the known 46 specimens, including the only confirmed female of the species. The rediscovery of *L. crenatus* in this museum's collection, as well as the identification of further unrecognised individuals in the Museum Victoria collection, reinforces the important and continuing role that museums have as repositories of natural history.

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